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Original Article

Less invasive cardiac surgery via partial sternotomy

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Abstract

Background: Less invasive cardiac surgery is widely adopted nowadays. Upper or lower partial sternotomy is an approach for less invasive cardiac surgery. We report results of less invasive cardiac surgery via partial sternotomy.
Methods: From August 1, 2009 to September 30, 2010, 35 patients underwent cardiac surgery via upper or lower partial sternotomy. The preoperative characteristics, operative variables, mortality, and morbidity were reviewed retrospectively.
Results: Thirty-five patients underwent cardiac surgery via partial sternotomy during the study period. Eleven patients (31%) were female. The mean age was 66 ± 11 years (range 38 to 88). Seven patients underwent aortic valve replacement via upper partial sternotomy. Simultaneous mitral valve replacement was done in one patient. Lower partial sternotomy was done in 28 patients. Sixteen patients received mitral valve replacement. Three patients underwent mitral valve repair. Concomitant tricuspid valve repair was done in eight patients. Two patients received aortic valve replacement. One patient had replacement of aortic and mitral valve replacement. One patient had repair of tricuspid valve. Two patients received LIMA anastomosis to the LAD. Two patients underwent emergent repair of the right ventricle. One patient had resection of myxoma in the left atrium. Direct cannulation of the aorta and right atrium was used for cardiopulmonary bypass in 15 patients (48%). Both antegrade and retrograde administration of cardioplegia solution was used routinely for myocardial protection. There was no mortality. Two patients developed respiratory failure. One patient suffered unstable sternum. One patient required conversion to full sternotomy. No patient suffered mediastinitis or groin wound infection.
Conclusion: Upper or lower partial sternotomy provides adequate exposure for various kind of cardiac surgery. Conventional cardiopulmonary bypass and cardioplegia solution administration can be used. The immediate preliminary outcome was acceptable.

Keywords: aortic valve replacement; cardiac surgery; mitral valve repair; mitral valve replacement; partial sternotomy

1. Introduction

A less invasive approach to cardiac surgery has been widely adopted in clinical practice.[1,2] Compared to conventional full median sternotomy, less invasive approach reduces incision size and surgical trauma. It has been reported to reduce morbidity, accelerate recovery, and shorten hospital stay.[3,4] Less blood transfusion, less postoperative pain, and greater patient satisfaction have also been reported. [5] The long-term outcome of minimally invasive cardiac surgery has been shown to be excellent.[3,6] There are several different incisions for minimally invasive cardiac surgery, including parasternal incision,[7,8] right mini-thoracotomy,[6,9,10] and partial sternotomy.[11–14]

Partial sternotomy provides adequate exposure.[1] We used upper or lower partial sternotomy for less invasive cardiac surgery in our hospital. We report here results of cardiac surgery performed via partial sternotomy in our hospital.

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2. Methods

2.1. Patients and procedures

This retrospective study was approved by the Taipei Veterans General Hospital Institutional Review Board with a waiver of individual patient consent. Thirty-five patients underwent cardiac surgery via upper or lower partial sternotomy in our hospital from August 1, 2009 to September 30, 2010 (Table 1). Seven patients received upper partial sternotomy, and lower partial sternotomy was performed in 28. The clinical characteristics, operative variables, morbidity, and mortality were collected and analyzed retrospectively.

2.2. Operative techniques: upper partial sternotomy

Incision for upper partial sternotomy was 8 to 10 cm long (Fig. 1). It began half way between the sternal notch and the angle of Loui, and ended above the fourth intercostal space. The upper partial sternotomy was performed from sternal notch toward the fourth intercostal space. It was then extended to the right fourth intercostal space by oscillating saw, forming a reverse L-shape sternotomy.[3] Care was taken not to injure the right internal thoracic artery. Cardiopulmonary bypass was established by cannulation of the ascending aorta and right atrium. Femoral artery cannulation was done for some patients with calcified ascending aorta. Cardioplegia solution was administered routinely by both antegrade and retrograde methods in every patient. Left ventricular venting was done by using a small flexible vent in the left atrium.

2.3. Operative techniques: lower partial sternotomy

Incision for lower partial sternotomy was 8 to 10 cm long. It began 1 to 2 cm below the angle of Loui and ended above the xyphoid process. The sternotomy began from the xyphoid process, extending upwards to the second intercostal space. It was then extended to the right or left second intercostal space by oscillating saw.[3] Care was taken not to injure the internal thoracic artery. The ascending aorta was cannulated. Femoral artery cannulation was done for some patients if the exposure was not adequate for aortic cannulation. Venous cannulation was accomplished by direct superior and inferior *vena cava* through the partial sternotomy. The administration of cardioplegia solution and left ventricular venting was the same as above.

Table 1
Cardiac surgery performed via partial sternotomy.

Procedures	Number
Upper partial sternotomy ($n = 7$)	
AVR	5
AVR and MVR	1
AVR and ligation of coronary artery fistula	1
Total	7
Lower partial sternotomy ($n = 28$)	
MVR	10
MVR and TV repair	5
MV repair, TV repair and Maze operation	2
AVR	2
CABG with LIMA to LAD	2
Exploration for hemopericardium and repair of RV	2
MV repair	1
AVR, MVR and Maze operation	1
MVR, TV repair and CABG x 1	1
TV repair for IE and severe TR	1
Resection of myxoma in the left atrium	1
Total	28

AVR = aortic valve replacement; CABG = coronary artery bypass grafting; IE = infective endocarditis; MV = mitral valve; MVR = mitral valve replacement; RV = right ventricle; TR = tricuspid regurgitation; TV = tricuspid valve.

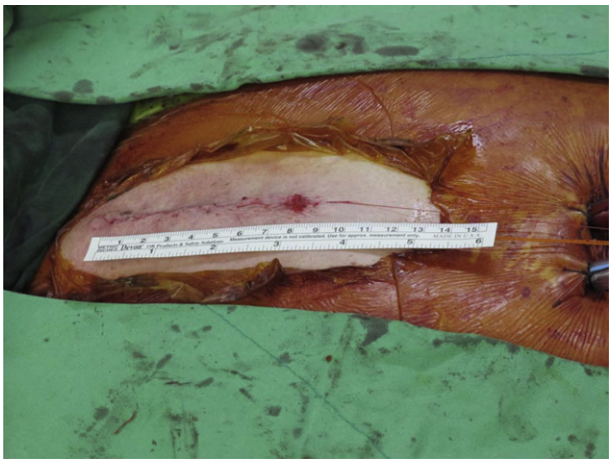

Fig. 1. The incision for upper partial sternotomy.

2.4. Other techniques

Conventional general anesthesia was used, the same as in conventional full sternotomy patients. Standard procedures for various cardiac surgeries, including aortic valve replacement, mitral valve replacement, mitral valve repair, coronary artery bypass grafting, tricuspid valve repair, and Maze operation, were done, as in conventional full sternotomy patients. Intraoperative transesophageal echocardiography was used in all patients. Flooding the operative field with CO_2 was used routinely in all patients. All procedures were completed without endoscopic or robotic assistance. All data are expressed as mean ± standard deviation or percentage, where appropriate.

3. Results

3.1. Less invasive cardiac surgery performed via partial sternotomy

Thirty-five patients underwent cardiac surgery via upper or lower partial sternotomy in our hospital from August 1, 2009 to September 30, 2010 (Table 1). Seven patients received aortic valve replacement via upper partial sternotomy. One patient had concomitant mitral valve replacement. One patient had concomitant ligation of coronary fistula. Lower partial

sternotomy was performed in 28 patients. Sixteen patients underwent mitral valve replacement. Mitral valve repair was performed in three patients. Aortic valve replacement was done in two patients. One patient received replacement of both aortic and mitral valve. Two patients underwent coronary artery bypass surgery with left internal thoracic artery anastomosis to the left anterior descending coronary artery without cardiopulmonary bypass support. Two patients received emergent partial sternotomy for exploration for hemopericardium. Tricuspid valve repair was done in one patient. One patient received resection of myxoma in the left atrium. Concomitant tricuspid valve repair was done in eight patients. Three patients received Maze III operation, using radiofrequency, in association with their mitral valve surgery. One patient received concomitant venous bypass to his right coronary artery (Table 1).

3.2. Patient characteristics

Patient characteristics are shown in Table 2. The age ranged from 38 to 88 years (mean 66 ± 11 years). There were 11 female patients (31%). Fifteen patients (43%) suffered from heart failure above NYHA class III. Seven patients (20%) had diabetes mellitus. Twenty-one patients (60%) had hypertension. Seven patients (20%) had atrial fibrillation. Thirty patients had echocardiography study before surgery. The mean left ventricular ejection fraction was 57 ± 11%.

Table 2
Patient characteristics.

Patient characteristics	Number (percentage)
Demography	
Age (y)	66 ± 11
Female gender	11 (31)
Height (cm)	160 ± 9
Body weight (kg)	62 ± 11
Body surface area (m^2)	1.66 ± 0.18
Body mass index (kg/m^2)	24.1 ± 3.4
NYHA	
I	8 (23)
II	12 (34)
III	11 (32)
IV	4 (11)
Comorbidity	
DM	7 (20)
Hypertension	21 (60)
PAOD	5 (14)
AF	7 (20)
COPD	7 (20)
Uremia under regular hemodialysis	1 (3)
Preoperative CVA history	1 (3)
Left ventricular function	57 ± 11%
Normal (LVEF ≥ 60 %)	14 (47)
Mildly impaired (LVEF: 50–59%)	11 (37)
Moderately impaired (LVEF: 35–49%)	3 (9)
Severely impaired (LVEF < 35%)	2 (7)

AF = atrial fibrillation; COPD = chronic obstructive pulmonary disease; LVEF = left ventricular ejection fraction; PAOD = peripheral arterial occlusive disease.

3.3. Operative variables

The average operative time was 4.4 ± 1.5 hours. Two patients receiving left internal thoracic artery anastomosis to the left anterior coronary artery and two patients receiving emergent exploration for hemopericardium did not undergo cardiopulmonary bypass. The cardiopulmonary bypass time for the remaining 31 patients was 148 ± 88 minutes. The aortic cross-clamping time was 101 ± 58 minutes. Fifteen (48%) patients received aortic and right atrial venous cannulation (Table 3). The mean blood loss was 688 ± 352 mL. The mean blood transfusion was 736 ± 680 mL. Six patients (17%) did not receive blood transfusion.

3.4. Operative outcome

The predicted logistic Euroscore was 8.86 ± 8.70 %. There was no mortality (Table 4). Two patients (6%) developed respiratory failure and needed prolonged ventilator support after surgery. One patient (3%) had postoperative bleeding and received re-exploration. One patient (3%) had an unstable sternum, which required rewiring. Conversion to full sternotomy was done in one patient (3%) receiving upper partial sternotomy for aortic valve replacement, because of inadequate exposure (Table 4). There was no mediastinitis. There was no groin wound complication in patients receiving femoral artery or vein cannulation.

4. Discussion

Less invasive cardiac surgery is widely used in clinical practice.[1,2] There are several different approaches for less invasive cardiac surgery, including parasternal incision,[7,8] lateral thoracotomy,[6,9,10] and partial sternotomy.[11–14] We use upper or lower partial sternotomy, which provide the same exposure of the heart and heart valves as full sternotomy. Therefore, surgeons are familiar with the exposure. Central aortic and venous cannulation are possible and the ascending aorta can be cross-clamped directly, without the need for endovascular clamping. Both antegrade and retrograde administration of cardioplegia solution can be done, so there is

Table 3
Operative variables.

Operative variables	Number (%)
Aortic cannulation	15 (48)
Femoral artery cannulation	16 (52)
Central venous cannulation	15 (48)
Femoral vein cannulation	16 (52)
Cardiopulmonary bypass time (min)	14 ± 8 88
Aortic cross-clamping time (min)	101 ± 58
Operation time (h)	4.4 ± 1.5
Blood loss (mL)	688 ± 352
Blood transfusion (mL)	736 ± 680
ICU stay (h)	67 ± 123
Intubation time (h)	153 ± 171
Postoperative hospital stay (d)	22 ± 20

Table 4
Operative mortality and complications.

Operative mortality and complications	Number (percentage)
Estimated logistic EuroScore	8.62 ± 8.70%
Mortality	0
Complications	
Respiratory failure	2 (6)
Re-exploration for bleeding	1 (3)
Unstable sternum	1 (3)
Conversion to full sternotomy	1 (3)
Mediastinitis	0
Groin wound complications	0

no compromise of myocardial protection. All the patients in this study received less invasive cardiac surgery via partial sternotomy without endoscopic or robotic assistance. There is no need to use long-shafted instruments or a knot-pushing device. The surgeon can utilize this technique with a very short learning period. There is no increased cost for the instruments or devices. When conversion is necessary, partial sternotomy can be easily enlarged to full sternotomy.[3] There is no need to sacrifice the internal thoracic artery.[8]

Most previous studies reported the results of mitral or aortic valve surgery.[2–10] In this study, we used partial sternotomy approach for a variety of different cardiac surgeries. Aortic valve replacement was performed via either upper ($N = 6$) or lower ($N = 2$) partial sternotomy. Concomitant aortic and mitral valve replacement was done via upper ($N = 1$) or lower ($N = 1$) partial sternotomy. All the mitral valve replacement ($N = 16$) or repair ($N = 3$) were done via lower partial sternotomy. Concomitant tricuspid valve repair was performed in eight patients. Three patients received Maze operation associated with mitral valve surgery. One patient underwent coronary artery bypass with greater saphenous vein graft to the right coronary artery in association with mitral valve replacement and tricuspid valve repair. Direct anastomosis of the left internal thoracic artery to the left anterior descending coronary artery was done in two patients. Two patients (5.7%) received emergent exploration via lower partial sternotomy for hemopericardium after traffic accident or coronary artery intervention. The right ventricles were repaired without cardiopulmonary bypass. One myxoma in the left atrium was resected via lower partial sternotomy. One repair of tricuspid valve for infective endocarditis and severe tricuspid regurgitation was performed via lower partial sternotomy. Partial sternotomy has been used for patients undergoing redo valve surgery.[3,10,15] All cardiac surgeries in this study were the first for the patients. Lower partial sternotomy has been used to repair congenital heart disease in pediatric patients by Chan and colleagues.[16] There were no congenital heart disease repairs in this study.

The cardiopulmonary bypass and aortic cross-clamping time were reported to be longer in less invasive cardiac surgery.[2,7,17,18] However, Mihaljevic et al reported significantly shorter aortic cross-clamping and cardiopulmonary bypass times in patients undergoing partial sternotomy.[3] The mean operation time in our study was 4.4 hours. The mean cardiopulmonary and aortic cross-clamping times were 148 and 101 minutes, respectively (Table 3). No comparison with patients undergoing conventional full sternotomy was made in this study.

There was one patient (3%) who underwent conversion from lower partial to full sternotomy due to inadequate exposure for mitral valve replacement (Table 4). Tabata et al reported that 24 of 907 patients required conversion from upper partial sternotomy because of bleeding, ventricular dysfunction, refractory ventricular arrhythmia, poor exposure, and other causes. Eight (33%) of these 24 patients died perioperatively. Twenty-one of 528 patients required conversion from lower partial sternotomy; none died postoperatively. The authors concluded that conversion from upper sternotomy was associated with serious morbidity and mortality.[19]

Bonacchi et al reported that partial sternotomy for aortic valve replacement reduced postoperative drainage, required less blood transfusion, shortened hospital stay, and provided a better cosmetic result.[20] They also showed earlier extubation and better recovery of respiratory function in patients receiving partial sternotomy. Compared to patients receiving lateral thoracotomy, less pain was reported in patients undergoing partial sternotomy.[21,22] The incidence of deep sternal wound infection was reported to be very low or zero in less invasive cardiac surgery.[23,24] There was no deep wound infection in our patients. Less invasive cardiac surgery has been reported to reduce bleeding and blood transfusion.[2,23–25] Six patients in our study (18%) did not receive blood transfusion during surgery. The mean blood loss was 688 mL, and the mean blood transfusion was 736 mL (Table 3). There was no groin wound complication in patients receiving peripheral cannulation (Table 3).

There are several limitations in our study. The patient number was limited, and this was a retrospective observation in one single hospital. We did not compare the effects and costs with conventional approach, because a variety of different cardiac procedures are included in this report. Long-term functional status and survival follow-up are necessary in any future study.

In conclusion, partial sternotomy is a safe alternative to full sternotomy for cardiac surgeries. It provides adequate and familiar exposure for a variety of cardiac surgeries. Conventional cardiopulmonary bypass and myocardial protection can be used. Less invasive cardiac surgery via partial sternotomy does not need long-shafted instruments or a knot-pushing device. Endoscopic or robotic assistance is not required, a shorter learning period can be expected, and additional cost for specific instruments or devices might not be necessary.

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